Bulletin 647

Ohio Guidelines For Production Of Machine-Harvested Tomatoes–1979

OSU Cooperative Extension Service
The Ohio State University

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The following publications have been helpful and many ideas and viewpoints have been borrowed from these publications.

Tomato Production and Mechanization in Indiana, 1978, ID. 95, Cooperative Extension Service, Purdue University
1977 Growing Tomatoes for Mechanical Harvesting, No. 36, Cooperative Extension Service, Cook College - Rutgers, The State University of New Jersey
Production of Tomatoes for Mechanical Harvesting: Suggested Practices and Procedures for the 1976 Season, Cooperative Extension Service, Pennsylvania State University
Recommendations for Production of Tomatoes for Processing, 1977, Cooperative Extension Service, University of Maryland.

Ohio Guidelines for Production of Machine Harvested Tomatoes for Processing

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For clarity, trade names have been included in some sections of this publication. This is not intended to discriminate against similar products not mentioned nor to recommend only those mentioned.

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The information given in this publication is supplied with the understanding that no discrimination is intended and no endorsement by the Ohio Cooperative Extension Service is implied. The authors have tried to assemble the most reliable information available to them at time of publication. Due to constantly changing laws and regulations, the Ohio Cooperative Extension Service can assume no liability for the suggestions. Individual processors may have specific pesticide suggestions. These should be consulted, too.

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1. INTRODUCTION

The tomato is the leading processed vegetable in the United States. In 1978, for example, more than 304,000 acres were planted to tomatoes for processing. The major states producing this crop for processing include California, Ohio, Maryland, Indiana, New Jersey, Pennsylvania and Michigan. Small acreages are found in several other states. Ohio growers have nearly 21,000 acres. Most of this acreage is located in northwestern Ohio, north of a line from Greenville to Sandusky. Ohio continues to rank second in the production of tomatoes for processing; California is the leading state.

Interest in machine harvesting of Ohio tomatoes started in 1960. Since then numerous growers with clay soils and sandy soils have mastered the techniques necessary for production of machine-harvested tomatoes. The interest in machine harvesting is increasing rapidly at present. Part of this increased interest is due to increased wages for hand harvest crews, increased cost of housing for labor crews, increased costs of Social Security and other benefits, and more governmental regulations affecting labor. There is also concern on availability of satisfactory labor for hand harvesting. Since local crews are frequently employed by growers with machines, there seems to be more certainty regarding this labor as compared with migrant labor.

Growers who have been successful with machine harvesting emphasize that more precise cultural and production practices are required than for hand harvesting. The systems approach must be followed with machine-harvested tomatoes, in that every single cultural practice must be performed properly since there is a close relationship among the various practices. For example, the field selected for machine harvesting must be uniform for both soil type and drainage, good bed preparation is essential, uniform plants are needed, pests must be controlled, and other cultural practices followed on a uniform basis to make the systems approach work. In the case of hand-harvested tomatoes, exceptions can occur, but with machines, all cultural and production practices must conform to the planned system to be successful.

Production of machine-harvested tomatoes is a capital intensive enterprise. Many thousands of dollars must be invested in the harvester and the ancillary equipment to do the job. Consequently the grower raising tomatoes for machine harvesting must be a professional tomato grower. No longer can the grower who plans on machine harvesting, look at tomatoes as a secondary enterprise. For a new grower just considering machine harvesting, he will need a minimum of 60 acres; later on, after he gains experience, he should be able to handle 90 to 100 acres per harvester, depending on the capacity of the harvester, availability of land, and his interest in continuing to grow tomatoes.

Success of machine harvesting requires close cooperation between the processor's field representative and the grower. This involves all aspects of production including field selection, size of acreage, variety selection, scheduling plantings, timing application of ethephon, and decisions on when to start the harvester in fields. Ohio processors have expanded plant capacity to handle machine-harvested tomatoes. In spite of this expansion, close cooperation must exist between the grower and the processor's representative to produce a quality product that is profitable for both grower and processor.

Profits and quality products can be achieved through "season stretching" or spreading the maturity over as long a harvest period as possible. This gives the processor and grower the longest possible time to operate their high-investment equipment. Close cooperation is needed between the grower and the processor's field representative to do the best possible job in lengthening the harvest season.

2. SITE SELECTION

Field selection is extremely important for mechanical harvesting. An ideal field would be level with uniform soil type, fertility, and tilth. The field should be well drained with both subsurface and surface drainage systems. Land leveling should be considered where uneven drainage and topography exist.

Well-drained, sandy-loam soils are highly desirable because they become warm earlier in the spring for early planting, have fewer problems of getting a stand by seeding, and usually have less harvester down time due to excessive rainfall than clay-loam soils. However, with proper management, many Ohio growers are successfully machine harvesting tomatoes on the clay-loam soils in northwestern Ohio.

Fields which will allow rows at least a quarter mile long will help reduce time lost in turning equipment at the ends of rows. Odd-shaped fields should be avoided. A north-south orientation may be desirable with direct-seeded fields to permit use of windbreaks, thus reducing damage from strong westerly winds on sandy soils.

Crop rotation is an important consideration. Tomatoes should follow a crop with low trash residue. Avoid following corn the previous season because of trash, high residual nitrogen, and possible herbicide residue. Tomatoes should not be planted where atrazine was used the previous year. Late harvest of corn and sugar beets may also prevent the preparation of beds in the fall on clay and clay loam soils. Soybeans and wheat appear to be good crops to plant the season previous to growing tomatoes.

There may be advantages of having two or more fields for the crop located several miles apart. This helps to reduce the risk from adverse localized weather conditions as well as different soil types to add flexibility to the production program. However, problems of moving equipment must be considered where some distance is involved.

3. SOIL PREPARATION

In all types of soils, it is advisable to prepare the bed for seeding as early as possible. Early seeding is usually possible since the selected fields are the best drained soils on the farm. Well-formed beds will help surface drainage. Some form of shaped bed is necessary, especially at harvest time because the bed surface must have the same profile as the harvester pick-up system. Plant beds on standard 60-inch centers to permit use of the present harvester or a new machine or custom harvester if the year and conditions require such action. (Some harvesters may require 66-inch centers.)

Beds should be formed at suitable times, depending on soil type. Most Ohio soils used for tomato production can be classified as sand, silt loam, and clay loam. The sand tends to be the easiest to work and modify at all times; the silt loam is best worked in the spring; and the clay loam is typically fall plowed to accomplish good spring soil structure through winter freezing and thawing. Thus, each soil type tends to have a slightly different requirement.

Sand. The major concern when preparing sandy soils is to maintain adequate surface moisture and prevent wind erosion. Winter cover crops leave the soil flat in the spring for seeding and transplanting. Some successful growers have used power bedders to form the beds prior to planting. Others form beds during cultivation by using rolling cultivators to throw loose soil to the center of the row. Lister shovels can be used to form wheel track furrows, and bed shaper plates are desirable for final shaping and smoothing. These same lister shovels can also be used to roughen the surface prior to an expected wind storm.

Early spring windbreaks for direct-seeded tomatoes can be achieved successfully in different ways. One way is to strip till the fall cover crop on 60-inch centers then seed. Early weeds and the cover crop are killed with a contact herbicide (Paraquat) just before the tomatoes emerge. The dead cover crop protects the soil until mechanical cultivation is needed to control new weed growth. Another windbreak idea is to till the soil 20 to 30 days before seeding, then sow spring oats in 30-inch rows. Shallow cultivate 6 to 8-inch tall oats before seeding tomatoes mid-way between every two oats rows. The tomatoes end up on 60-inch centers, and both oats and tomatoes can be cultivated mechanically until wind protection is no longer necessary.

Cover crops can also be sown in the drive rows and turn around areas but this offers limited protection.

Silt Loam. Silt loam soils tend to be well drained and easy to work in the spring. Some fall land leveling may be desirable, but fall plowing and fall bed forming is usually undesirable since the soil tends to become too compact in the spring. Raised beds should be established on this soil one to two weeks prior to seeding or transplanting. A rainfall on the bed is highly desirable for necessary moisture and compaction to form a good seed bed. Prior to seeding, till the top one inch of the bed for weed control. Deeper tillage may be desirable for transplanting.

Clay Loam. Clay loam soils are the most difficult soils to work early unless fall beds are prepared directly after fall plowing. Figure 1. The best preparation technique for fall beds has been to fall plow and disc for coarse leveling. Land leveling to fill small pot holes is also desirable. Further leveling and sloping a field to some outlet for surface drainage may be advantageous, but is not normally done. Beds made with power tillers and

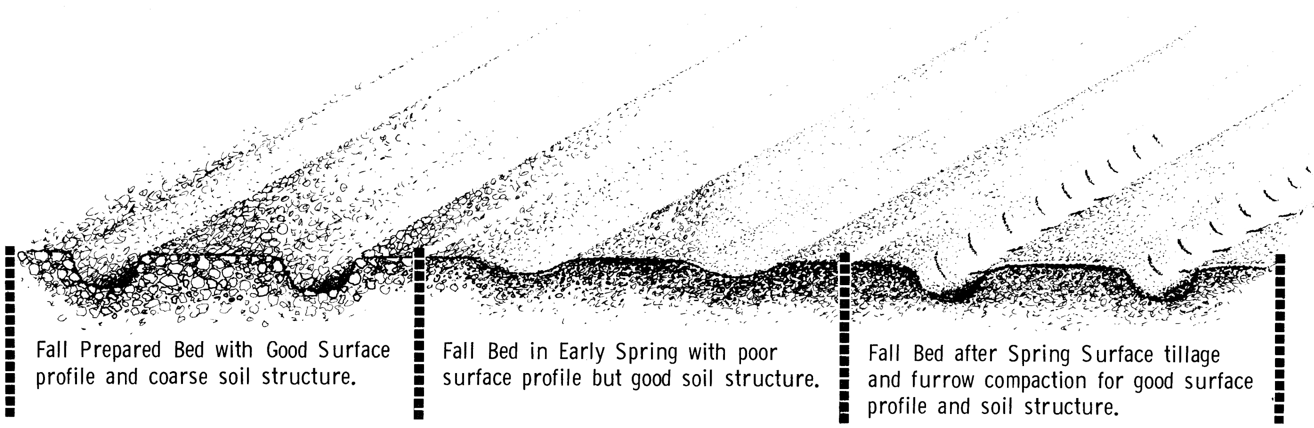

Figure 1. Fall Bed Preparation on High Clay Content Soils.

shaper plates tend to do a more uniform job of distributing soil to the center of the bed than just shaper plates on a frame. The raised bed should be about 6 inches high and 42 to 48 inches wide at the top. Make furrows on 60-inch centers. The top of the bed should be as level as possible and low; avoid unfilled areas. Mid-winter preparation of "slabby" soil is acceptable if enough time is allowed for freezing and thawing to develop a desirable soil structure before spring.

A bed 6 inches high in the fall will usually be less than 3 inches high in the spring. A normal observation and mistaken decision has been that the beds should be rebuilt by again taking soil from the furrow and putting it on top of the bed. Do NOT rebuild in the spring. Fall beds can essentially be re-established to a desirable height in the spring by furrow compaction. Some growers overlap one row of a 3-row bedder so that the tractor wheels compact all furrows. The wetter the furrow, the higher the resulting bed will appear. The wetter parts of the field always have the deepest furrows.

Soil particle or clod size after bed preparation in the fall can be highly variable with clods up to 4 inches in diameter. However, by spring, the bed surface will be quite uniform in shape, and most soil particles will be no larger than 1/8 inch in diameter. After spring rains, the raised bed surface area dries more rapidly than the furrow area. Usually a dry soil layer less than 1 inch thick forms and appears to be lying on a "moist" zone. This moist zone tends to be a uniform distance from the surface when the surface is level. Any tillage of the wet zone appears detrimental to the soil structure and soil moisture profile; however, the dry zone can be shallow tilled for weed control.

If excessive rain in the fall and winter prevents bed forming, there are two alternatives. If the spring weather is dry, beds can be made in the spring. Proper rainfall will be essential for good germination and emergence. If the spring weather is wet, beds can be made by compacting furrows with a tractor on 60-inch centers. In all cases, it is best to fall plow.

Most growers expect that in some years the fall bed system will not be completed in the fall. However, advantages of fall beds, when it is possible to make them, are well worth the time and effort.

The fall and spring bedding system is a form of controlled traffic tillage. No heavy equipment is ever allowed to compact the general growing area during the life of a crop. The system may also provide some surface drainage which is advantageous for tomato seedlings and transplants.

Fall bed-forming requires a high commitment to early decisions for land use the following year. It also requires a significant amount of fall work and favorable weather.

4. FERTILIZER AND LIME PROGRAM

Fertilizer programs have much influence on the success of machine harvesting. Uniformity of fruit maturity is affected by fertilizer programs, especially the use of nitrogen. Ideally the nitrogen for the crop should be mostly depleted when most of the fruits start to turn red. To accomplish this, avoid heavy applications of nitrogen to tomatoes which are to be machine harvested. Sometimes where tomatoes follow corn in the rotation, the nitrogen carry over from the corn can cause excessive vine growth of the tomatoes. Remember this point when planning a fertilizer program.

Lime Needs. Take a soil sample from the field to be planted to tomatoes as early as possible. There are various laboratories including the REAL Laboratory at the Ohio Agricultural Research and Development Center, Wooster, where suitable soil analysis can be made. County Extension offices can supply information on the procedures to follow in taking soil samples.

The importance of soil pH in relation to fertilizer efficiency cannot be over emphasized. Correct the pH first, then apply the fertilizer. Apply sufficient limestone to maintain a pH 6.5. Many soils in northwestern Ohio have the soil pH in this desirable range; a soil test will determine need for limestone.

Direct-seeded plantings. The soil test will give some indication as to the quantities of P_2O_5 and K_2O to be applied. Apply most of the P_2O_5 and K_2O prior to plowing or field tillage. Band placement of some P_2O_5 may be advantageous, especially under cool conditions. If soil tests are not available, an application of 125 pounds of P_2O_5 and 250 pounds of K_2O per acre should be suitable for most soils in northwestern Ohio except for the light-textured soils (sandy loams) where additional K_2O may be needed.

Some growers have successfully used the Purdue University method of applying a dilute solution of 10-34-0 on the seed at planting time. For use on seed, mix at rate of 1 pint of the 10-34-0 liquid fertilizer to 4 pints of water, and apply the diluted solution at a rate of 1 pint per 100 feet of row. With sandy soils, use at one-half the rate suggested.

Other growers have successfully applied fertilizer, high in phosphorus, in bands 2 inches to the side of and about 2 inches below the seed. Apply no more than 10 pounds of N, 40 to 50 pounds of P_2O_5, and 10 pounds of K_2O per acre in band(s).

Most growers use a nitrogen rate for direct-seeded tomatoes that is less than for transplants. Check with processor's field representative for specific suggestions. The seasonal total should range between 40 and 70 pounds of N per acre, depending on soil type, previous crop, general soil fertility level, and variety being grown. Past experience in growing tomatoes for machine harvest will help to indicate the N application for specific soils and variety types. On silt loams, loams and clay loams, the fertilizer may be applied before plowing. On sandy soils, about 25 percent of the N may be applied as a sidedress application. The sidedress application should be made between the time the plants have 2 to 3 leaves and before the flowers in the first cluster are open. Contact processor's field representative for experiences regarding sidedress application of N.

Transplants. A soil test will help to determine amounts of P_2O_5 and K_2O to apply. This fertilizer, along with nitrogen, should be applied before plowing except with sandy soils where some nitrogen may be applied as sidedress application.

If no soil test has been made, a typical application on the loams, clays, and clay loams would be approximately 125 pounds of P_2O_5 and 250 pounds of K_2O per acre. (Check with processor's field representative for specific suggestions.) The nitrogen rate would be 50 to 100 pounds per acre. Additional K_2O may be needed on the sandy and light-textured soils.

Apply starter fertilizer high in phosphorus at planting time. Typical analyses include 21-53-0, 10-52-17, 10-55-10. Follow the manufacturer's directions which are usually about 3 pounds of the fertilizer in 50 gallons of water with 1/2 pint of solution per plant. Liquid fertilizers such as 10-34-0, 8-16-8, and similar analyses can be used if diluted. With higher plant populations, more starter fertilizer will be needed per acre as compared with hand-harvested fields.

Since uniformity of maturity is so important, methods of applying fertilizer can be important. Avoid overlapping fertilizer swaths because this can cause uneven growth of tomato plants.

Maintain pH in desirable range (pH 6.5) so that most micronutrients as well as major nutrients will be most readily available.

The major problem in planning a fertilizer program for transplants is the nitrogen rate. When machine harvesting was started in Ohio, growers were using high rates of N. These high rates delayed maturity, caused excessive vine growth, and frequently reduced yields of machine-harvested tomatoes. Only sufficient N should be present for early plant establishment and early fruit development, plus enough to maintain plant vigor. Some of the determinate, early-maturing varieties may require more nitrogen than late varieties to obtain fast plant growth before fruit setting occurs. Growers should discuss this phase of the fertilizer program with the processor's field representative. Probably no more than 80 to 90 pounds of N per acre will be needed in most situations. Where tomatoes are following heavily fertilized crops, less nitrogen may be needed - 40 pounds or even less.

Micronutrients. Manganese deficiency may occur in some high pH soils in northwestern Ohio. This can be corrected by spraying with manganese sulfate at 4 to 5 pounds of the chemical per acre. Thoroughly cover foliage with a minimum of 50 to 60 gallons of solution.

Some growers and processors apply some borax on fields intended for tomatoes. Plant analyses have indicated some fields may be in the low to deficient zone. One half to one pound of boron per acre, applied as broadcast application, will meet the needs of a tomato crop.

Plant Analysis. Growers can have leaf samples analyzed at the REAL Laboratory, Ohio Agriculture Research and Development Center, Wooster, Ohio 44691. Kits can be purchased at county Extension offices. These analyses, if made in late June and again just prior to harvest, will give important information on which to make changes in future fertilizer practices. Information on sampling procedures is available from county Extension offices. These plant analyses can give important information on adequacy of major and micronutrients.

5. IRRIGATION

Few Ohio growers have invested in irrigation for production of tomatoes for processing. Part of this reluctance has been due to difficulty in finding an economic source of water. Also there has been some uncertainty on the expected yield increases from irrigation. Growers raising tomatoes in the light-textured soils (sands, sandy loams and similar soils) should be considering irrigation. Growers in heavier soils can profitably use irrigation to improve the production of tomatoes for machine harvesting. From a long-range viewpoint, irrigation will help all growers raising tomatoes for machine harvesting if the following management practices are observed:

1. An adequate moisture level is necessary for seed germination, seedling emergence, and during early plant growth, fruit set and early fruit enlargement. If moisture becomes a limiting factor during any of these periods, uniformity of fruit maturity cannot be attained.

2. With direct-seeded plantings, apply 1/2 inch of water, using a slow application rate, if rain does not occur following seeding. The application of water during this period will reduce the soil crusting problem. Continue to irrigate the plantings as needed.

3. Another critical period for soil moisture is from just prior to the time the blossoms open through the time of fruit set. Use irrigation at the critical period, if rainfall is inadequate. Following fruit set, variations in soil moisture can cause blossom end rot. Careful use of irrigation during the rapid enlargement period can help to reduce the blossom end rot problem.

4. Irrigation immediately following transplanting can help to reduce transplanting shock. A light application of water - 1/2 inch, for example - at this time can help to insure a uniform stand.

5. Irrigation can also improve the effectiveness of surface-applied herbicides such as diphenamid (Enide), chloramben (Amiben G), and metribuzin (Sencor or Lexone).

6. Irrigation should be discontinued when ripening starts. Too much water, either rain or irrigation, during the ripening period will reduce the fruit quality.

7. In planning an irrigation program, do not apply excessive amounts of water at any time. Plan your program so there will be a safety factor - in case rain occurs soon after irrigation.

8. An irrigation system can be used for frost protection, but special nozzles are needed. For specific suggestions, contact Mel Palmer, Extension Agricultural Engineer, Department of Agricultural Engineering, The Ohio State University, 2073 Neil Avenue, Columbus, Ohio 43210

6. VARIETY SELECTION

A tomato variety must meet several requirements to be suitable for machine harvest. Most important, the fruit should be sufficiently firm and tough-skinned to withstand machine and bulk handling. Growers should work closely with the processor's field representative in selecting varieties.

Selected varieties should be capable of setting fruit uniformly over a wide range of temperature conditions to insure concentrated fruit set and a high percentage of ripe fruit recovery. Additional requirements include small-plant growth habits, concentrated flowering, good fruit-setting ability, uniform ripening, and ability of ripe fruit to store on the vine, then separate freely from the plant without stems, and be resistant to fruit cracking. These factors affect the efficiency of machine harvest. Varieties should be resistant to Fusarium and Verticillium wilts.

Use varieties with a succession of maturities, particularly early varieties, so harvest peaks can be spread and delivery gluts avoided.

The processor's needs must be considered in variety choice because of quality requirements for different products being manufactured such as juice, soup, catsup (ketchup, catchup), sauce, and paste. This becomes critical in production for wholepack canned tomato production where stem scar and core must be small enough to pass coreless raw product standards, and fruit-peeling characteristics must be suitable for automated steam or lye peeling.

7. STAND ESTABLISHMENT

Field Seeding. The ideal system for complete mechanization of processing tomato production would be field seeding of the entire crop. However, most growers have not yet developed the techniques and confidence in seeding to plant the majority of their machine-harvested acreage by this method. Further, varieties and cultural methods have not been developed that will result in fruit ripening as early from seeded as from transplant crops. Season stretching is important and consequently transplanting will still be necessary in Ohio's industry.

Stand establishment from seeding vs. transplanting can save considerably in time and labor costs, reduce chance of disease introduction with transplants, and gives greater flexibility in time of planting, variety selection, and plant populations. However, stand establishment by seeding has not been adopted widely, chiefly because of difficulties in emergence on the clay-loam soils and weed-control problems. Methods and equipment are available to greatly improve the odds of obtaining a satisfactory stand by seeding, and weed control can be satisfactory with proper management and field selection. For persons who have only used transplants, it is difficult to develop the patience and confidence necessary to allow time for a seeding to emerge and develop. A 90 percent survival is usually the minimum acceptable limit for a satisfactory stand with transplants, whereas a 50 to 70 percent stand is satisfactory for seeded fields because the closer spacing and the vigorous growth of seedlings will fill in blank spots more readily than transplants.

Seeding System. Successful seeding depends on a complete system of seedbed preparation, precise placement of seed and starter fertilizer, use of an anti-crustant, and proper compaction of the soil around the seed.

Seedbed preparation is covered in Section 3. Keep in mind that seed should be placed at a uniform depth in uniformly warm, moist soil. The seedbed must be relatively firm to accomplish uniform seeding and achieve the uniform emergence, growth, and development necessary for a favorable once-over harvest. However, excessive seedbed preparation is not needed since this may increase the crusting problem.

A seeder must have a means of accurately controlling planting depth. Figure 2. Planters with wheels in front and behind the seed furrow shoe usually do the best job in controlling depth. The furrow shoe is usually adjustable to set the depth. Successful plantings can be obtained by seeding 5/8 to 3/4 inches deep. The seed-feeding mechanism should drop 4 to 7 seeds per clump in the firm, moist soil behind the base of the shoe. The feeder tube should be designed to prevent soil from plugging the tube when operator is setting the equipment at the start of a row. Spray a liquid starter fertilizer on the seed (see fertilizer Section 4).

Use an anti-crustant on the clay-loam soils in Ohio. Some planters place the anti-crustant just over the seed clump, and others fill the seed furrow. Regardless of the type used, there should be sufficient material to completely fill the seed furrow above the seed. This may require as much as 22 to 24 cubic feet of material per acre of the continuous feed types of planters. Apply the anti-crustant with a positive-feed mechanism. Horticulture-grade vermiculite, Perlite, and composted sawdust have all been used successfully. Do not use fresh sawdust and ground corn cobs because of the possibility of toxic compounds which will kill the seedlings.

Soil should be firmed around the seed from the side with some type of wheel. The split press wheel should also form a small ridge of soil and anti-crustant over the seed row to prevent soil from washing into the row. This soil over the row will usually crust and prevent emergence. Flat press wheels will form a depression that fills with soil from a heavy rain and prevents emergence even though an anti-crustant is used.

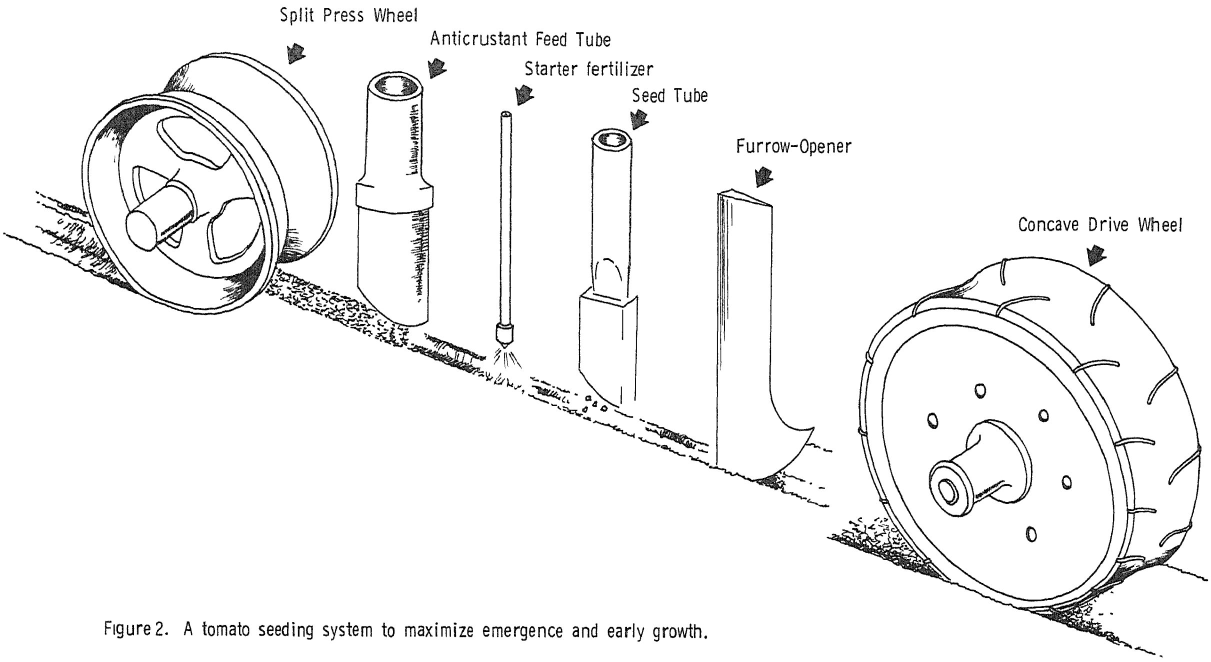

Figure 2. A tomato seeding system to maximize emergence and early growth.

Plant Spacing. A usual row spacing of 60 inches is dictated by the wheel spacing of the harvester and the tillage equipment. Determine precise row spacing after discussion with a harvester company representative. Some harvesters may require 66 inches. Clumps of 4 to 7 seeds each should be on 6- to 9-inch spacings, depending somewhat on variety and soil fertility. This will result in a desirable 3 to 5 plants per clump that should not be thinned. About 8 ounces of seed per acre is required depending on seed size, viability, and the degree of de-fuzzing of the seed. Use de-fuzzed seed.

Double rows will usually give higher yields due to more uniform ripening. Because twin-row culture requires more management, it is not recommended for growers just getting started in machine harvesting. Planting, cultivation, and weed control become more difficult. The rapidity of ripening requires considerable management skills. Further, vine training is usually necessary with twin-row culture.

Time of Seeding. Seeding in Ohio should be done between April 20 and May 20. Before April 20 the soil is usually too cold, and a frost may seriously damage a good seeding. After May 20, the crop may not mature because 110 to 125 days are needed for full maturity, depending on variety. Varieties which germinate well at low soil temperatures should be used for late spring seedings. Be sure to check with processor's field person on this matter. A temperature of 55^{o}F. at the 1-inch depth at 1 PM is considered minimum for seeding.

Consider the seeded crop only for the mid- and late-season crops, with transplants providing the early crop. Be sure to consult with processor's field person on varieties and a planting schedule to maximize the length of the harvest season. In all cases, be patient during seed emergence. Cold, dry soil will delay emergence, possibly up to 30 days. Seeds will usually survive unless serious crusting occurs. Any stand above 50 percent emergence, if uniform, should be saved.

Pre-Germinated Seeding. One of the more reliable methods for obtaining a stand from field seeding is to germinate the seed prior to planting, mix the seed with an artificial medium that will serve as an anti-crustant and source of nutrients for the small seedlings, and then to plant a "plug" of this mixture. This has been referred to as "plug-mix planting." A mixture that has been successfully used:

1 bu. of Peat Lite Mix*
1/2 lb. of Magamp (7-40-6, med. granules)
1/2 oz. tomato seeds
3 to 4 qts. of water to moisten the mix slightly

One bushel of this mix will plant about 600 clumps using 1/4 cup per plug.

Seed can be germinated by mixing the desired amount of seed in moist vermiculite in a plastic bag and placing this in an area where temperature is about 80°F. for 48 hours. Germination can also be done in the peat-lite mix, but if adverse weather occurs and planting cannot be done, it is easier to store a small bag of germinated seed than a large volume of mix. The seed-vermiculite mix can be kept for 5 or 6 days at 40°F. If longer storage is required, it is best to germinate another batch.

The germinated seed-vermiculite mix and the peat-lite medium can be mixed with a rotating cement mixer, screw-type feed mixer, or other type of good mixer. Thoroughly mix prior to adding the water. Use only enough water to make the mix slightly moist. Excess water will prevent the mix from feeding properly in the planter.

A planter is available from the Mechanical Transplanter Co., Holland, Michigan. Some growers have also developed their own plug-mix planters. Figure 3. One of the most critical aspects of this method of seeding is proper depth placement and compressing the soil around the plug from the side so that a slight amount of mix is at the soil surface to serve as an anti-crustant. Shallow planting and improper compaction will result in drying of the plug and the wind blowing it away. Excessively deep planting will allow soil to wash over the plug; crusting may result which will restrict emergence.

Transplants and Transplanting. Transplanting is much more costly in time, labor and equipment than seeding but is necessary to have early fields for harvest. Most growers use bare-root plants. Use only good quality "certified" plants. They should be stocky, uniform in size and age, and properly hardened. Sorting may be necessary to remove excessively large or small plants to improve plant uniformity for more uniform ripening.

Container-grown transplants may also be used for planting. However, research in Ohio has indicated no advantage of these specially produced plants over good quality southern field-grown or northern bare-root greenhouse plants. Container-grown plants may store better if adverse conditions prevent timely planting.

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*Commercially available as Jiffy Mix, Redi-Earth, and possibly others. Jiffy-Mix has the Magamp in the commercial mix.

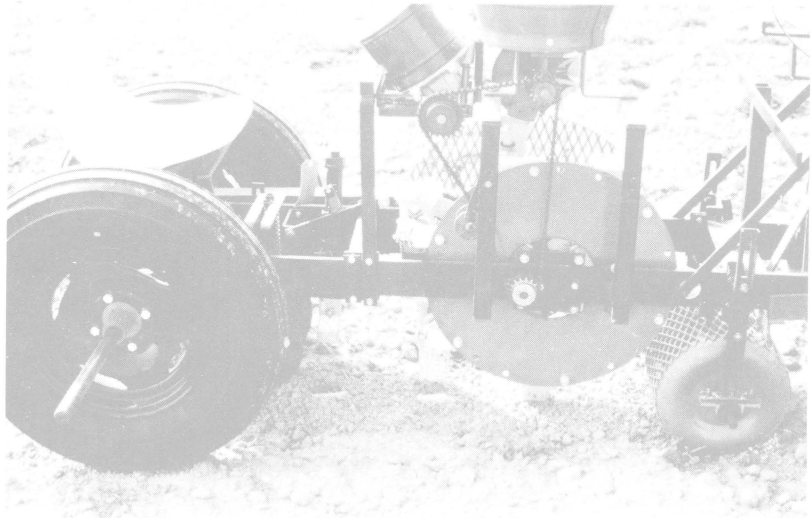

Figure 3. A "Plug-Mix" Planter which has been modified with an adjustable front roller for depth control and fitted with a seeder box to drop seed in the cups holding the mix. This seeder would not be used when pre-germinated seed is incorporated into the mix.

Row spacing should be determined by harvester and other equipment. Within-row spacing should be from 9 to 10 inches depending somewhat on variety. Some early varieties may be grown in twin rows to give adequate yields. Twin rows can be 16 to 20 inches apart on beds spaced on 60-inch centers and within-row spacings should be no less than 12 inches. Remember that special transplanting and cultivation equipment is necessary for twin-row culture. Vine training may be required for some varieties. Growers just starting to produce for mechanical harvest should consider only a small acreage of twin rows to gain experience in this more management-demanding production system.

Transplanting usually can start near May 1 in Ohio depending on weather conditions and the consideration of risk of frosts in early May, which may require replanting. Generally, there should be three or more plantings, a week to 10 days apart and with 3 or more varieties, so that not all fields will ripen at once. Consult with your field person on planting schedules. Planting can continue until June 10 to 15, if necessary, to have an extended season and if seeded fields will not provide for late-season harvests.

8. WEED CONTROL AND CULTIVATION

Efficient operation of the tomato harvester requires weed-free fields at harvest time. Weeds, especially foxtail and nutsedge, slow the harvester and make it difficult to harvest the crop satisfactorily. Where perennial weeds are a problem, the grower should try to control these weeds in the rotation before tomatoes are planted. For specific suggestions on these perennial weed control, see the Ohio Agronomy Guide, copies are available from county Extension offices. Fields selected for tomatoes should not have received any atrazine, or other long-lasting herbicides, within the past year.

Mechanical Cultivation. The primary purpose of cultivation is to control weeds. Sometimes a combination of chemical weed control and cultivation is needed to control weeds and to maintain bed shape. Weeds may emerge after herbicides have been applied. Such weeds should be destroyed by cultivation. Use of various types of knives for shallow cultivation will not destroy the effectiveness of diphenamid (Enide), chloramben (Amiben G), and pebulate (Tillam).

Chemical Weed Control. Much progress has been made in recent years in chemicals to control weeds in tomato fields. When applied at the proper time, and with good equipment, approved chemicals give good weed control. Poor results are usually due to improper application, poor timing in relation to rains, inadequate records on specific weed populations, inadequate rates of herbicide for particular soil types, and poor follow-up of cultivation. Check with processor's field representative for any restrictions on use of any pesticide or herbicide before applying it.

1. Weed control in field-seeded tomatoes - Apply 6 to 12 pounds per acre of Enide 50 WP as a preplant incorporated treatment or apply at time of seeding as a pre-emergence treatment. Use the higher rate on heavier soils and for better control of many broadleaf weeds. On reshaped beds, a direct spray of up to 6 pounds of Enide 50 WP when plants are 5 to 6 inches tall, may be helpful. Do not apply more than 12 pounds of Enide 50 WP per acre in one season. Enide can be used up to 1 month after seeding. Where Enide is incorporated, depth of incorporation should be 1/2 to 2 inches. Enide is subject to leaching, and if heavy rains occur, weed control may not be satisfactory, and injury may occur to seedlings under cool, wet conditions.

If weeds emerge before tomatoes, apply one quart of Paraquat in 50 to 60 gallons of water per acre just before the tomato seedlings emerge. Paraquat will kill all emerged plant seedlings including tomatoes. Observe label for safety precautions.

Granular Amiben may be used at layby time. Apply 30 to 40 pounds of Amiben 10G per acre. Foliage must be dry, and field must be weed free. Do not use on sandy soils. Results may be erratic if rains (or irrigation) do not occur soon after application.

Sencor or Lexone 50 WP can be applied on established plants after plants have reached the 5- to 6-leaf stage. Use 1/2 to 1 pound of Sencor 50 WP or Lexone 50 WP per acre in 20 to 75 gallons of water. Do not apply more than 2 pounds of Sencor 50 WP or Lexone 50 WP in one season. Follow manufacturer's label for special precautions. Some varieties may be injured by Sencor or Lexone. This herbicide controls many broadleaf weeds such as velvet leaf, flower-of-the-hour, purslane and Jimson weed.

2. Weed control in transplanted tomatoes - Apply 1 to 2 pints of Treflan 4EC per acre and incorporate immediately into the top 2 to 4 inches of soil. Use lower rate on sandy soils and up to 2 pints on heavy soils. Expect poor weed control when applied to wet areas. Slight stunting of tomato plants may result if weather is cool and damp.

Where nutsedge (nutgrass) is a problem, use Tillam. Apply pre-transplanting 2/3 to 1 gallon of Tillam 6E or 40 to 60 pounds of Tillam 10G per acre. Incorporate to a depth of 2 to 3 inches immediately after application. Use lower rate on sandy soils and up to one gallon on heavier soils. Apply on well-worked soil that is dry enough to permit thorough mixing. Do not use Tillam as pre-plant treatment on direct-seeded tomatoes.

Tillam may be applied post-transplanting. Apply either 2/3 gallon per acre of Tillam 6E as a directed spray to the soil or broadcast 40 pounds of Tillam 10G per acre when plants are dry. Incorporate to a depth of 2 to 3 inches immediately after application. Do not apply within 8 days of harvest. Tillam may be applied at layby on direct-seeded tomatoes. See label for details.

Enide may be used with transplants either as pre-transplanting or as post-transplanting treatment. See label for details.

Sencor or Lexone 50 WP may be used on direct-seed or transplants after plants have reached the 5- to 6-leaf stage or when transplants have recovered from transplant shock. Apply 1/2 to 1 pound of Sencor or Lexone 50 WP per acre as a directed spray in single or multiple applications with a minimum of 14 days between treatments. Do not apply within 7 days of harvest. Do not apply more than 2 pounds of Sencor or Lexone 50 WP during one crop season. Be sure to read label for precautions.

Amiben 10G can be used on transplants after the transplants are established or at layby with either transplants or direct-seeded tomatoes. Field must be weed-free when Amiben 10G is used. Foliage must be dry. Use 30 to 40 pounds of Amiben 10G per acre.

9. CULTIVATION AND BED MANAGEMENT

Some form of mechanical cultivation is necessary to control weeds and maintain soil aeration. Bed forming and re-shaping can usually be done in the same process. Cultivation must start early when the weeds are small. As the harvest season approaches, the bed surface must conform to the same profile as the harvester pick-up. Any clods or ridges left on the bed surface will go into the harvester and cause problems - especially in a wet fall.

Rolling cultivators and power tiller cultivators tend to work best. Power tiller rotational speeds should be kept as slow as possible on clay soils. Lister shovels can be used to maintain the furrows, and shaper plates should always follow the tillage tools.

It is common on all soil types to rip a narrow slot down the wheel track furrows after or during the last cultivation. These slits are up to 18 inches deep and are made to store and dispose of excess surface water after heavy rains.

10. DISEASE CONTROL

The concept of a systems approach was discussed in the introduction of this manual. Disease control is an important integral in that approach. The grower should closely follow spray recommendations given in latest OSU Extension Service Bulletin 459, "Vegetable Insect and Disease Control for Commercial Growers," and recommendations from the processing company field persons.

Mechanical Vs. Hand-Picked. In the next few years, major cultural practice and varietal changes will accompany the shift from hand-picked to mechanical harvesting. Following is a preview of these changes and their possible influences on disease development.

A. Fall plowing and bedding:
These are definite helps for disease control. The overwintering capacity of most disease organisms is reduced if infested tissue is thoroughly worked in the soil prior to winter.

B. Shift from transplants to direct seeding:
The early season appearance and severity of some diseases are associated with the use of transplants. Direct seeding can reduce the occurrence and early appearance of foliar diseases-early blight, Septoria, late blight and certain bacterial diseases. There will probably not be any effect on severity of fruit rots. Producers can expect some damping off and root rot problems with direct seeding.

C. Increased plant populations:
With increased plant density, thorough fungicide spray coverage will be more difficult. Greater attention must be paid to sprayer calibration; perhaps increasing gallonage and penetrating the lower leaves in dense plant canopy.

D. Varietal changes:
Mechanical harvested varieties are more determinant and smaller in size than hand-picked varieties. Determinate varieties tend to have a concentrated fruit set and may be more susceptible to stress. Many of the varieties are newly developed, and some lack important disease resistances. Generally, these varieties appear to be more affected by foliar diseases.

E. Rotation practices:
Producers will shorten rotations on better sites. Most diseases increase if rotation intervals are shortened. This will be particularly true with fruit rots and wilts.

F. Delayed harvests:
Fruit rots are expected to increase with mechanical harvest. The major reason is that ripe fruit, which is more susceptible to rots, may be held in the field longer.

Important Tomato Diseases in Ohio

Foliar Diseases. Major foliar diseases in Ohio are early blight, bacterial speck and spot, Septoria leaf blight, gray leaf spot, and late blight. Symptoms of these diseases can be very similar, making identification difficult. Early identification is extremely important as control strategies will differ depending on the disease. Help in identifying diseases is available by sending samples to the OSU Plant Disease Clinic, 1735 Neil Avenue, Columbus Ohio 43210. Contact the county Extension office for details.

Control - foliar diseases.

1. Reject transplants with disease symptoms. Southern grown transplants can carry diseases which will be difficult to control by later fungicide sprays. Therefore, early application of appropriate fungicides is necessary.

2. Spray with fungicides at regular intervals. Follow the suggestions contained in OSU Extension Service Bulletin 459 or recommendations from processor's field persons. Shorten spraying intervals during the period of rapid plant and fruit development. Frequent plant wetting may also require more frequent applications.

3. Apply sufficient nitrogen to grow moderately vigorous plants. Premature nitrogen and potassium deficiency increases disease susceptibility.

4. Rotate tomatoes on a 3-year schedule.

Fruit Rots. Rotted fruits greatly influence operation of the harvester. Anthracnose is the most important fruit disease and requires early protective sprays. The extent of anthracnose development depends on soil type, previous cropping, variety, general nutritional level and the extent of defoliation by other diseases. Fruits on plants with sparse foliage are usually more subject to infection than are those with good leaf cover. The fungus can attack green fruit. It enters the fruit wall and remains dormant until the fruit begins to ripen. Once within the fruit, the fungus is protected from fungicides. Also the fungus can increase in young foliage injured by flea beetles and foliar diseases. This emphasizes the importance of early season protection.

Early and late blight attack both foliage and fruit. Late blight rot can usually be found on the fruits whenever it is present on the foliage. Early blight frequently causes severe defoliation without causing fruit rot. Early blight appears on the foliage every year in Ohio, whereas late blight seldom occurs. Buckeye fruit rot occurs sporadically, usually in localized areas. The same is true of Rhizoctonia-soil rot, and both are favored by flash rains that temporarily flood the soil surface.

Control - fruit rots.

1. Follow a regular spray program. Start early, perhaps 2 to 3 weeks after transplanting or after emergence of seedlings. Continue program at 7- to 10-day intervals until harvest. Late season protection is important because anthracnose can be severe. Difolatan 4F (machine harvest only) gives excellent control of anthracnose. (Some people are allergic to Difolatan 4F.)

2. Use crop rotation. Do not plant tomatoes in same field more often than once every third year.

3. Maintain good plant foliage cover.

Bacterial Diseases. Bacterial diseases occurring in Ohio are bacterial spot, speck, wilt and canker. Bacterial wilt is a southern disease and occasionally is introduced on transplants. It cannot overwinter in Ohio, and is seldom a serious problem. Canker can be extremely serious, but seldom occurs at economic levels. Bacterial spot and speck have become serious problems. Both diseases produce symptoms on the leaves, stems, flowers and fruit. It is impossible to distinguish between them on the foliage, but speck produces small pin-point lesions on the fruit, and spot produces larger crusty lesions. Both lesions are only surface deep and seldom cause serious problems for the industry. However, where dark spots are present on the peeled tomatoes and if the lesion is callused over, specks may show up in the juice or products after processing. Foliage and flower infection can result in severe defoliation and flower drop. Early season protection is necessary to protect the foliage and flower clusters. Failure to control in the early season may result in yield loss, delayed maturity and split set problems.

Control.

1. Reject transplants that show symptoms of these diseases.

2. Apply fixed coppers mixed with other fungicides. Three or 4 sprays may be necessary, starting 1 to 3 weeks after transplanting or seedling emergence.

3. Do not save your own seed. These diseases may be seed borne.

Summary of Disease Control Programs.

1. Follow a 3-year rotation. Do not plant following potatoes or peppers.

2. Do not save your own seed.

3. Use only disease-free transplants.

4. Follow a regular spray program. Start early. In the first 3 or 4 sprays, add a copper fungicide to protect against bacterial disease. Continue spraying until harvest.

5. Adjust and calibrate sprayers to give good, uniform coverage.

6. Check fields on a regular basis. Report unusual problems to the Extension service or processing company representative. Follow latest state and/or company recommendations.

7. Good plant growth and development conditions should be provided throughout the season.

11. INSECT CONTROL

Insect problems may shift somewhat as cultural practices change for mechanical harvesting. The shift from transplants to field seeding will result in more problems with flea beetles and Colorado potato beetles. These insects can destroy a seeding in a day or two if not controlled.

Increased plant population will result in more dense plant canopies which will make spray coverage more difficult and give insects like worms, loopers and crickets a good place to hide and feed. Wireworms may be a greater problem where sod crops precede the tomatoes. Larger fields will require a more thorough scouting of fields to catch an insect infestation before high, damaging populations build-up. The grower and/or processor's field person should take time to walk the fields regularly (weekly would be ideal) to see if insects and insect damage can be found.

Detailed insect control recommendations are available in latest edition of OSU Extension Service Bulletin 459, "Vegetable Insect and Disease Control for Commercial Growers." Processors also have policies concerning pesticide use and specific suggestions for their growers - these should be observed. Read the pesticide label and follow all directions. Labels change and latest recommendations should be used.

12. ETHEPHON AS A RIPENING AID

Ethephon is a plant regulator which, when applied to tomatoes, results in an increase of ethylene in the tissues and triggers the ripening action of mature green fruit. Advantages for use of ethephon for machine harvest are:

1. Hastens ripe fruit accumulation so that a once-over harvest of a higher percentage of ripe fruit can be made as much as 5 to 7 days earlier than normal.

2. Reduces the amount of green fruits that may need to be sorted on the harvester.

3. Aids in spreading out the harvest schedule if properly planned and with the aid of processor's fieldmen.

4. Permits late plantings to be harvested before frost.

5. Usually increases yields from fields suffering from split-set conditions.*

6. Helps overcome the delayed ripening of fields with excessively vigorous plants.

Time of Application. Ethephon is effective in ripening only fruits that have reached the mature green stage of development. It has little or no effect on ripening fruits that are immature or in which the coloring process has already been initiated. The objective, therefore, is to have the maximum number of fruits on the plants at the mature green stage at time of treatment. With most of the processing varieties, this occurs when 5 to 30 percent of the fruits on the plants are pink or red. Ohio research suggests the greatest response to

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*Split-set means that certain environmental conditions, especially high temperature, have caused some flowers to fail to set fruit during the bloom period. This results in uneven maturity, which seriously affects yields from a once-over harvest.

an ethephon application occurs when 5 to 20 percent of the fruits by count show color.

To check fruits to determine the mature green stage, cut several fruits with a sharp knife. If the seed cavities are filled with gelatinous pulp and the knife does not cut any seeds (the seeds are pushed aside into the pulp), the fruits are considered to be mature. Such fruits should also show a change to a light green or white color.

Effectiveness of an ethephon application is also influenced by the plant condition at the time of application. Plants that are wilted due to water stress will likely not respond satisfactorily. If plants are in a wilted condition, even though the fruits are at the proper stage of maturity, delay application until after a rain (or irrigation) and the plants have returned to a normal turgid condition. Furthermore, applying ethephon when plants are wilted, will likely cause defoliation, depending on the temperature.

Rate of Application. Label recommendations are to use 3-1/4 pints of the commercial 2-lb.-per-gal. ethephon formulation per acre (0.8 lb. ethephon) under normal conditions in Ohio. However, under cooler temperatures late in the season, use up to 6-1/2 pints per acre (1.6 lb. ethephon) absorption is less at lower temperatures. Also, 0.4 lb. per acre (1-5/8 pints) may be sufficient for early maturing varieties that are less vigorous or mature when temperatures are high and the rate of absorption is high.

Remember that ethephon initiates ripening and has little, if any, effect on rate of ripening. Temperature has the greatest influence on rate of ripening after it has been initiated. Therefore, do not increase the rate of application, expecting to increase the rate of ripening. The rate of application should be governed primarily by the air temperature at the time of application and expected temperature during the next 2 or 3 hours. (See section on temperature effect.)

Uniform and adequate coverage of the fruits and vines is essential, regardless of the rate of material used. Forty to 80 gallons of spray solution per acre usually gives good coverage depending on foliage density and type of sprayer used. Boom-type sprayers appear to provide the more desirable spray coverage, although ethephon has been satisfactorily applied with properly adjusted and operated air-blast sprayers. Some applicators have improved coverage with air-blast sprayers, especially in heavy vine growth, by making two passes over the treated area, the second pass being perpendicular to the first. However, be sure to reduce the material added to the spray tank to one-half so as not to exceed the desired final rate by the double spraying. Also, be sure the second pass is made as soon as possible following the first, preferrably before the first has dried completely. If not, the effectiveness may be reduced significantly.

Aerial applications with spray rates of 10 to 15 gallons per acre provides satisfactory coverage under most aerial application conditions in Ohio. The higher rate should be used on most field-seeded plantings and on varieties and plantings with dense foliage.

Ethephon not only promotes fruit ripening but initiates aging and senescence of leaves. If plants are under stress at the time of application, severe leaf yellowing and eventual drop will likely result. Moisture stress, disease, insect or hail damage, low plant vigor due to root damage or insufficient available nutrients will increase the foliage injury. Loss of foliate may be beneficial for mechanical harvest, but may also expose the fruits to high sunlight, which may result in poor color development. Leaf effects will occur regardless of rate used, but will be more severe at higher rates and under high temperatures. When temperatures are in upper 80's and 90's, defoliation can be very serious. Further, transplanted plants will usually show more loss of foliage than seeded plants.

Temperature Effect. Temperature influences absorption and translocation of the chemical. Generally, the higher the temperature immediately following application, the greater will be the rate of absorption and thus the effectiveness of the chemical. The temperature at the time of application should be above 65^{o}F., and the temperature should be "on the rise." Absorption of ethephon is very slow at temperatures below 65^{o}F. Further, the material should not be applied at temperatures above about 90^{o}F. because the plants will probably be under moisture stress, the ripening response will not be as favorable as desired, and more leaf damage will occur.

High temperatures hasten natural fruit maturity and ripening and cause a general reduction in plant vigor. Therefore, the response from ethephon applications made at relatively high temperatures will be accelerated. Watch fields closely and be prepared to harvest when the fruits are at the correct degree of ripeness.

Rainfall Effects. After application of ethephon, a period of three hours is necessary for adequate absorption. If rainfall occurs before this minimum time, do not treat the area again because this is not permitted under the label restrictions. Keep your delivery schedule in mind to determine the area to be treated, and remember that it is possible to get response from an application that received rainfall before the 3-hour minimum time.

Variety Response. Most present varieties will respond to ethephon applications. Differences may occur between early and late-maturing varieties. These differences may be more closely related to temperature conditions at the time of treatment, and thereafter, than to the varieties. Differences may also occur between the highly determinant, concentrated fruit-set types and the less determinant and later varieties. These differences are related to the relative number of mature green fruits on the plants at the time of treatment. Field observations suggest that varieties that have a loose fruit attachment when ripe, tend to have more detached fruit after ethephon treatment. Check with your company field person on variety response.

Holding Tank Mixes. It is best to apply the spray mixture as soon as possible after adding ethephon to the water. A few hours delay will probably not be serious, but if it is necessary to hold the material overnight, discard it, and mix a new batch. Proper planning with an "eye on the weather" should permit application without undue delay.

Mixing with Pesticides. Do not apply as a tank mix with insecticides or fungicides.

Fruit Quality Aspects. Ethephon usually has no detrimental effect on fruit quality. The over-all quality of a lot of fruit should be improved because, with proper harvest management, harvesting treated fields should be early enough to prevent excess over-ripe and rotted fruits. On the other hand, there may be more over-ripe fruit in the load, if harvest is delayed beyond optimum ripeness. Therefore, watch the crop closely and harvest it at the proper time.

Time of Harvest. Optimum harvest could be 10 to 12 days after treatment for an early season crop and up to 3 to 4 weeks from treatment later in the season. The average time interval is 14 to 18 days after treatment. Temperature greatly affects these time periods, so be prepared.

Growers should start the harvest before the maximum amount of usable fruit is on the vines. Delaying harvest may result in excessive over-ripe and rotten fruits in later harvests. Do not spray more acreage at one time than can be harvested in 3 or 4 days. (See page 23 for pointers on use of Ethephen.)

13. PREPARATION FOR HARVEST

Learn as much about the machine as possible before going to the field. The dealer will provide much useful information. Talk with other farmers who have owned and operated a similar model. Become aware of how the machine will operate in adverse field or weather conditions and be prepared to take proper action. Maintain an inventory of repair parts.

Be sure to clean the machine daily or more frequently, if necessary. Cleaning is necessary in both dry and wet conditions because rotted tomatoes cause mud build-up. After cleaning is a good time for lubrication, inspection and repair of any defective parts. Some operators have been successful in cleaning the machines by dry scraping, while others prefer high pressure liquid or steam cleaning.

Develop an appreciation for the true capacity of the machine in tons per hour. Avoid basing the decisions on the maximum capacity value since maximum values occur only under ideal field conditions. Instead, assume the first half of the crop will be harvested at 50 percent maximum capacity. Harvest crews should improve with proper management, but the average machine capacity is not likely to be higher than 85 percent maximum capacity. Typically 15 percent of the operating time will be used for rest periods, trailer changes, turns, unplanned maintenance and repair, and other miscellaneous delays.

Discuss delivery schedules with the processor's field representative and have enough trucks and trailers available to keep the harvester operating to meet delivery schedules. A "rule of thumb" is to have the capacity of 1/2 to 1 ton per acre contracted on wheels. For example, if 80 acres are contracted, wagon and truck capacity for 40 to 80 tons are needed.

Trucks and large semi-trailers can be maneuvered in the field if it is dry. Large semi-trailers need a 100-plus horsepower tractor hitched to a tandem axle fifth wheel. The tandem axles can be powered from the tractor PTO to improve traction. Under wet conditions, large trucks must be parked outside the field. Tomatoes may be delivered to the truck with scissors lift or dump cart trailers. Two of these trailers are necessary. All wagons and trailers should have wheels spaced the same as the row spacing. This is especially important when opening fields.

Open fields from the center and work toward the inside of the field. When the turn around time becomes too long, open up the center again. Allow approximately 35 feet at the ends of the rows to turn around without backing.

The technology of sorting green or rotten tomatoes and trash is changing rapidly. Automatic or electronic sorting devices are avilable which reduce hand sorting, but they are expensive. Growers purchasing machines for the first time should thoroughly examine all information before purchasing a costly automatic sorting system.

Some processors may accept loads with minimum field sorting because they do some in-plant sorting at the receiving station. Some field sorting will likely be necessary regardless of the type or age of harvester purchased. Consequently a crew will probably be needed for the harvesting operation.

Select sorters carefully and well in advance. They will represent the major part of your crew. Consider the need for having people for the entire season. Also consider methods of payment, pay scales and incentives. Additional benefits such as a handy source of good, cool drinking water and scheduled rest periods can make for good employee relations.

Train sorters with actual fruit that demonstrates acceptable grade. Also identify any defective type fruit that must be sorted. Stress the importance of safety while the machine is in operation.

It is best to assign sorters to "stations" along the conveyors. Each station has a specific assignment. For instance, station 1 can remove over-ripe; station 2 clods; station 3 greens, and station 4 other defects. The number of sorters in each station will depend on the field and crop conditions. Keep the work load even among sorters by rotating positions every half hour or at the end of a specific number of rows.

Designate one person as a sorting supervisor. This person should be located at the loading elevator. The supervisor may hire or fire sorters, determine payroll information such as time keeping and train sorters to improve their efficiency. If one person is given this responsibility, it relieves the operator and grower of the sorting burden, providing a continuous check on sorting efficiency. Some growers even allow the supervisor to determine machine speed because he or she is in a position to see the flow of fruit passing each sorter.

The need to mechanize, however, is here and now. It will continue to be essential that much planning preceed the actual operation of the machine. The successful grower always has a well thought out contingency plan for the unusual or problem year.

Summary - Do's and Dont's of Using Ethephon

Do:
1. Plan ahead and discuss your plan with the processing company field person.
2. Read and follow label instructions.
3. Treat only limited acreage to gain experience.
4. Treat when maximum number of fruits are mature green.
5. Thoroughly cover all fruits and vines.
6. Use the correct amount of chemical - 3 1/4 pints per acre.
7. Treat when temperatures are between 75 and 85, if possible.
8. Treat when there will be at least 3 hours before a rain.
9. Treat only the amount of acreage which can be harvested in 3 to 4 days.
10. Harvest when fruits are at the correct ripeness.

Do Not:
1. Use excessive amounts - 3 1/4 pints are sufficient under all cases except where temperatures are below about 70°F.
2. Treat entire acreage at once.
3. Treat when plants are wilted.
4. Treat when plants are stressed from insects, disease, nutrient deficiency, or severe defoliation.
5. Mix with other pesticides.
6. Hold tank mixes over-night or longer than 2 to 3 hours.
7. Expect treatment to accelerate fruit ripening.
8. Treat varieties that normally do not stick on the vine when ripe. Ethephon treatment may increase shattering of fruit.
9. Expect treatment with ethephon to replace good management practices in the entire production system.

14. ECONOMICS ARE FAVORABLE FOR MACHINE HARVESTING TOMATOES IN OHIO

The economics of mechanically harvesting processing tomatoes continues to be very favorable. Recent technology changes in the use of ripening materials, better varieties, bedding practices, and machine adaptations have caused the economic feasibility of mechanical harvesters to continually improve. Continued improvements in machine harvesting cultural practices are needed and will continue to be made, but as of the Fall of 1978 machine harvesting is very favorable when compared with hand harvesting.

Some of the negatives expressed by people involved relate to the high cost of machines, the potential risk of leaving acres unharvested in case of a wet season, the need for a minimum number of acres or tons for spreading overhead costs and the need for lengthening the harvest period.

An extensive economic feasibility study was conducted in 1970 and '71 by The Agricultural Economics and Rural Sociology Department of Ohio State University and it was determined then that the machines could make a profit. Since that time interested farmers, processors and researchers alike have kept a keen eye on the objective of continued improvement in management practices. This concerted effort has paid off.

The Ohio processing tomato Budget for machine harvest showing 1979 anticipated costs and returns is shown in Table 1.

Table 1. 1979 Processing Tomato Production Budgets Machine Harvest.

ITEM	EXPLANATION	PRICE PER UNIT	YIELD/ACRE[1/] 17 T.	23 T.	29 T.	YOUR BUDGET
RECEIPTS		$68.00/T.	$1156	$1564	$1972	$
VARIABLE COSTS						
Plants	11,000	$10.00/M	$ 110	$ 110	$ 110	
Fertilizer[2/]						
Starter(10-34-0)	5 gal.	$ 1.00/gal.	5	5	5	
N	80 lb.	$ .20/lb.	16	16	16	
P_2O_5	175 lb.	$ .18/lb.	32	32	32	
K_2O	275 lb.	$ .08/lb.	22	22	22	
Lime	1000 lb.	$ 9.00/T.	5	5	5	
Chemicals						
Herbicide						
Amiben 10%G	35 lb.	$ .62/lb.	22	22	22	
Treflan	1 qt.	$26.00/gal.	7	7	7	
Fungicide						
Copper	2 gal.	$ 5.30/gal.	11	11	11	
Difolitan	2.5 gal.	$ 9.75/gal.	24	24	24	
Insecticide						
Sevin	6 lb.	$ 1.80/lb.	11	11	11	
Thiodan	1 qt.	$18.50/gal.	5	5	5	
Ripener						
Ethephon	5 pt./A. on 3/4 of A.	$42.00/gal.	20	20	20	
Hired Labor						
Setting	13 hrs.	$ 3.00/hr.	39	39	39	
Hoeing	7 hrs.	$ 3.00/hr.	21	21	21	
Sorting	19,26,33hrs.	$ 3.00/hr.	57	78	99	
Crop Insurance			20	20	20	
Inspection		$ .25/T.	4	6	7	
Fuel, Oil & Grease[3/]			21	21	21	
Repairs[3/]			27	27	27	
Custom Hauling		$ 5.00/T.	85	115	145	
Social Security	$142,163,184 @ 6.13%		9	10	11	
Workers Compensation			6	7	8	
Unemployment Insurance			0	0	0	
Transportation for labor			1	1	1	
Miscellaneous[4/]			5	5	5	
Interest on Oper. Cap.[5/]	6 mo.	9.5%	20	20	20	
Total Variable Costs			$605	$660	$714	
FIXED COSTS						
Housing Charge[6/]			$ 5	$ 5	$ 5	
Labor Charge	14,16,18hrs.	$ 4.50/hr.	63	72	81	
Mach. & Equip. Charge[3/]			172	172	172	
Land Charge			55	85	115	
Management Charge	5% of Gross Income		58	78	99	
Total Fixed Costs			$353	$412	$472	
TOTAL COSTS[7/]			$958	$1072	$1186	
RETURN ABOVE VARIABLE COSTS			$551	$ 904	$1258	
RETURN ABOVE TOTAL COSTS			$198	$ 492	$ 786	

EXPLANATION OF BUDGETS

Receipts:

Yield Levels: The budget shows three yield levels, 17, 23, and 29 tons per acre. Some farmers in Ohio are achieving yields in the mid 30's but there are also yields less than 17 tons each year. The 23 ton level is 2 to 2.5 tons above the state average of recent years.

The yield levels for machine harvested tomatoes when compared with budgets prepared for hand harvest tomatoes show one ton less per acre. In 1970-71 the machine harvested tomatoes were averaging two tons less than hand harvested. With current technology there are farmers getting higher yields on their machine harvested acres than on the hand harvested. Because of a concern about wet harvesting seasons when it may be impossible to get over all the acres the machine harvest tonnage was budgeted at one ton less than hand harvest tonnage.

Price for Tomatoes: The $68.00 price level is not to predict or dictate the price level of 1979. There will be, as normal, a variation in prices paid for tomatoes in Ohio in 1979. Part of this price variation is explained by different grade standards and by different receiving procedures among companies.

Variable Costs:

Plants: The 11,000 plants per acre may be a little higher than most farmers are setting. One reason for this higher figure is to allow for any replanting costs which farmers might experience. The price of plants vary and $10.00 per thousand plants represents an expected average cost for 1979.

Field seeding of machine harvested tomatoes is possible and actually can result in a lesser total cost. One fear about field seeding is the possibility of not getting a stand. Budgets show that field seeding competes very favorably with the plants even considering the higher risk of replanting.

Fertilizer: The quantities of fertilizer varies from field to field depending on soil tests, prior crops, yield goals, etc. A consistant thought throughout the industry is that nitrogen fertilizer on machine harvested tomatoes should be limited to enhance uniform rippening. The price of nitrogen is listed at 20¢ per pound of actual N, an estimated cost for the forms of nitrogen used on tomatoes.

Chemicals: The herbicide, fungicide, and insecticide use varies tremendously from season to season, processor to processor and from farm to farm.

The herbicide program in the budget shows Amiben 10%G and Treflan. Since these budgets were prepared Sencor and Lexone have been approved as herbicides and many farmers will be using them.

The use of Ethephon has been one of the management practices which has improved the success of machine harvest. The recommended application rate for Ethephon varies from 3-1/4 to 6-1/2 pints per acre with the higher rates being used later in the season.

Labor: The section of the budget which relates to labor expense refers only to hand labor. The labor for operating machines is included as a part of the labor charge under fixed costs. The rate of $3.00 per hour is an estimate of what growers will be paying in 1979. The minimum wage for labor in 1979 is $2.90 per hour. The $3.00 does not include social security, workers compensation or unemployment insurance.

Labor for setting tomatoes was determined by assuming 98 minutes to set one acre of tomatoes and eight people working to keep a 3 row planter operating (8 people x 98 minutes = 784 minutes ÷ 60 minutes = 13 hours).

Hoeing labor varies considerably depending on the results of the chemical weed control. In 1970 and '71 farmers were averaging 7 hours of hoeing per machine harvested acre.

Sorting labor is entered at progressively higher hour requirements with increasing yields. Usually the harvester field speed is slowed down as higher yielding tomatoes are harvested. The economic studies of 1970-71 vividly pointed out that the harvester should not be required to slow down for a lack of people on the machine. It is cheaper to hire additional labor than to slow down a $65-$80,000 machine. In 1978 as few as 2 sorters and as many as 18 sorters were observed on machines. Several factors affect the number of sorters placed on a harvester. Some of the major factors are: number of weeds, number of rotten tomatoes, and percent ripe. If processors try accepting more field run tomatoes by doing more in plant sorting farmers will likely experience less sorting costs than shown in the budget.

Crop Insurance: The rate being quoted for crop insurance by private companies is $4.50 for each $100 of coverage. Crop insurance is also available through Federal Crop Insurance for a cost ranging from $16 to $26 per acre. If a farmer does not carry insurance through an outside insurer he has actually chosen to insure himself. When a loss is encountered without an outside insurer it is amortized over the year of loss plus years of no loss and in such case insurance is still a cost to be considered. This insurance entry can be considered risk coverage; be it the risk of drought, hail, excess water, pests or various other factors which might reduce yields.

Inspection Fees: These are fees which are paid to the Ohio Department of Agriculture for carrying out the state inspection program.

Fuel, Oil and Grease: The fuel, oil and grease cost of $21 is to pay for all operations except hauling of tomatoes to market. Field operations which make the fuel for tomatoes greater than for general crops include bedding, 2 or 3 more cultivations, 6 to 8 more applications of pesticides, and more fuel for harvesting.

Repairs: The repair cost in the budget of $27 is to pay for all machinery repairs except those related to hauling. Table 2 contains repair estimates of $1.47 per acre for the bedder, $1.22 per acre for the transplanter and $14.44 per acre for the harvester plus $1.71 per hour for the tractor used to do the added field operations which are not needed for general crop production.

Custom Hauling: An often quoted rate for custom hauling is $5.00 per ton. This should pay for the truck and labor. If a farmer does his own trucking and owns the equipment then he will encounter the costs of depreciation, interest on investment, repairs, insurance, housing, fuel, oil, grease and labor. These could well amount to $5.00 per ton.

Social Security: The social security rate for an employer for 1979 is 6.13%, the employee will have a similar cost. The employer's share of this cost is shown for the hand labor in the budget. The social security cost for machine labor is included as a part of the hourly rate.

Workers Compensation: The workers compensation rate for hand labor is 2.782 percent. This cost is shown for the hand labor in the budget. Hand labor includes setting, plants, sorting and hoeing. The workers compensation rate for machine operator labor is 9.712 percent and is included as a part of the hourly rate for such labor.

Unemployment Insurance: Unemployment insurance has not been included in these cost estimates. Unemployment insurance must be paid once an employer pays $20,000 in cash wages per calendar quarter or employed 10 or more employees in each of 20 or more weeks. Unemployment insurance should not be a concern until 125 or more acres are grown for mechanical harvesting.

If a farmer has once become subject to unemployment insurance he cannot stop paying until he experiences an entire year without wages. Therefor it is possible for a farmer to be subject to the insurance payments even if he grows under the 125 acre estimate.

The 125 acres was determined in the following manner. The July, August and September quarter, tomato harvesting period, would likely be the high labor cost time. If 125 acres were grown and the sorting cost were $78 per acre then a total sorter labor bill of $9750 would be experienced leaving $10,250 for machine harvest labor. This margin left for machine labor should not cause a farmer to get to the critical $20,000 figure.

Transportation for Labor: Several farmers pay transportation costs for labor as they move from their previous employment to Ohio. This charge was calculated using $.01 per mile x 1600 miles making $16.00 per worker. It is assumed the workers work 75 percent in tomatoes and 25 percent in other crops making the cost to be charged to tomatoes $16.00 x 75% or $12.00. If 10 workers per machine is the average for the season then the cost to be charged to tomatoes is $120.00. Using the machine over 90 acres results in $1.33 per acre.

Miscellaneous: The $5.00 miscellaneous entry is to allow for such expenses as utilities, soil tests, small tools, record keeping and miscellaneous supplies.

Interest on Operating Capital: Money is expended for several items as the tomato crop is planned and continues to be invested until the crop is harvested and money is received. This money is either borrowed and interest paid or owned capital is used which could have been invested elsewhere with an anticipated return. Totaling the expenses in the budget which are encountered prior to harvest: plants $110; fertilizer and lime $80; pesticides $80; setting and hoeing labor $60; crop insurance $20; fuel, oil and grease $21; repairs $27; social security and workers compensation on setting and hoeing labor $6; transportation of labor $1; miscellaneous $5 for an operating pre-harvest expense of $410. Most of this money is invested for 6 months, April 15 through October 15, some for a longer and some for a shorter period. ($410 x 9.5% annual rate x $\frac{\text{6 months}}{\text{12 months}}$ = $19.48 per acre.) (Some of the expenses listed are advanced to the farmer until settlement with the company. An example would be the cost of transplants. If this is the case the interest calculated should not include that expense item.)

Total Variable Costs:

The total variable costs represents costs which would not be encountered if tomatoes were not grown. Also they are costs which would change if the land were used for another crop. Variable costs tend to be short term costs and the amount of these costs will not be known until after the decision has been made to grow tomatoes in any one year. This is contrasted with fixed costs which will continue even if tomatoes are not grown or if some crop other than tomatoes are grown. The total variable costs have been estimated at $605, $660 and $714 with the respective yields of 17, 23 and 29 tons per acre, Table 1.

Fixed Costs:

Housing Charge: A farmer in northwest Ohio recently made an investment in labor housing, that investment has been used to calculate a housing charge. A total of $12,000 was invested for 30 workers. One group of costs incurred with this type of investment includes depreciation, interest, insurance, repairs, and taxes. The initial investment is multiplied by an annual percentage as these costs are amortized over the expected life of the building. The estimated annual percentage for each cost item is: depreciation 12.5% (8 year life), interest 4.75% (same as the average investment x 9.5%), insurance .02%, repairs 2.15% and taxes .08% for a total of 19.5%. It has been approximated that 75 percent of the time of the employees using these facilities would be spent working in tomatoes. Other costs annually include trash pickup, utilities, and a land charge. These have been estimated at $691. No more than one field worker for every two acres should be needed for completing the harvest. Applying all of these factors the annual cost for labor housing would be $41.00 per acre. ($12,000 investment x 19.5% annual cost x 75 percent usage on tomatoes + $691 other costs ÷ 30 workers annual capacity x 1/2 worker per acre = $41 housing cost per acre.)

Operator Labor Charge: The operator labor charge is in recognition of the labor required for all machine operation except hauling of tomatoes

The labor for hauling is a part of the custom charge. Also included in the operator labor is the time spent for purchasing supplies and making repairs. The number of hours of operator labor have been increased from 14 to 16 to 18 hours per acre as yields increased from 17 to 23 to 29 tons.

Machinery and Equipment Charge: The $172 equipment charge per acre recognizes the harvester, transplanter and bedder costs plus costs of tractors, tillage equipment, cultivators, sprayers, pickups, wagons, etc. The $172 is high when compared with the $40 machinery charge that has been budgeted for hand harvest tomatoes and $30 machinery charge for corn and soybeans in 1979.

The budgets for specialized tomato equipment, Table 2, show total costs of depreciation, interest, repairs, insurance and housing for the bedder, transplanter and harvester of $142 per acre. The budgeted $30 machinery charge for corn and soybeans plus the $142 for specialized tomato equipment yields a total $172 for machine harvest tomatoes.

Table 2. Budgets for Specialized Tomato Equipment[1].

Budget for 90 H.P. Tractor Used in Specialized Tomato Operations

			Annual Cost		Cost/Hr.
Purchase Price[2]	$21,400				
Salvage	- 7,400				
Depreciation	$14,000	÷ 7 years	= $2,000	÷ 500 hours	= $4.00
Interest[3]					
$\frac{\$21,400 + \$7,400}{2}$	=$14,400	x 9%	= 1,296	÷ 500 hours	= 2.59
Repairs	$21,400	x 4%	= 856	÷ 500 hours	= 1.71
Insurance	$21,400	x 0.2%	= 43	÷ 500 hours	= .09
Housing	$21,400	x 0.7%	= 150	÷ 500 hours	= .30
Totals			$4,345		$8.69

Fuel, Oil and Grease
9 gal. of fuel per hour x 50¢ + 10¢ per hour for oil & grease= 4.60
Total cost of operation per hour $13.29

Budget of Sled Bedder

			Annual Cost		Cost/Hr.
Purchase Price[2]	$ 3,300				
Salvage	- 1,000				
Depreciation	$ 2,300	÷ 7 years	= $330.00	÷ 90A.	= $3.67
Interest[3]					
$\frac{\$3,300 + 1,000}{2}$	=$ 2,150	x 9%	= 193.50	÷ 90A.	= 2.15
Repairs	$ 3,300	x 4%	= 132.00	÷ 90A.	= 1.47
Insurance	$ 3,300	x 0.2%	= 6.60	÷ 90A.	= .07
Housing	$ 3,300	x 0.7%	= 23.10	÷ 90A.	= .26
Totals			$685.20		$7.62

Tractor for bedding $13.29 per hour @ 2 acres per hour	= 6.65
Labor for bedding $5.00 per hour @ 2 acres per hour	= 2.50
Tractor for cultivating with bedder $13.29 per hour @ 1½ A/hr.	= 8.86
Labor for cultivating with bedder $5.00 per hour @ 1½ A/hr.	= 3.34
Total cost of bedding, including 2 cultivations with bedder	$28.97

Budget for Transplanter Cost

			Annual Cost		Cost/Hr.
Purchase Price[2]	$ 1,850				
Salvage	- 300				
Depreciation	$ 1,550	÷ 10 years	= $155.00	÷ 76A.	= $2.04
Interest[3]					
$\frac{\$1,850 + 300}{2}$	=$ 1,075	x 9%	= 97.00	÷ 76A.	= 1.28
Repairs	$ 1,850	x 5%	= 93.00	÷ 76A.	= 1.22
Insurance	$ 1,850	x 0.2%	= 4.00	÷ 76A.	= .05
Housing	$ 1,850	x 0.7%	= 13.00	÷ 76A.	= .17
Totals			$362.00		$4.76

Budget for Tomato Harvester

					Annual Cost		Cost/Hr.
Purchase Price[2/]	$65,000						
Salvage	- 25,000						
Depreciation	$40,000	÷	7 years	=	$5,714.29 ÷ 90A.	=	$ 63.49
Interest[3/]							
$65,000 + 25,000 / 2	=$45,000	x	9%	=	4,050.00 ÷ 90A.	=	45.00
Repairs	$65,000	x	2%	=	1,300.00 ÷ 90A.	=	14.44
Insurance	$65,000	x	0.2%	=	130.00 ÷ 90A.	=	1.44
Housing	$65,000	x	0.7%	=	455.00 ÷ 90A.	=	5.06
Totals					$11,649.29		$129.43

Fuel, Oil and Grease 5.40

Operator Labor Cost

8 hr. of machine operation per day
x2 operators
16 hours
+2.8 hours per day for cleaning and maintenance
18.8 hours x $5.00 per hour = $94 per day ÷ 4.73 A. per day = 19.87

Tractor cost 1.5 hours per acre x $13.29 = 19.94

Total $174.64

1/ The rates of performance for each the bedder, transplanter and harvesters are based on information learned during the 1970-71 mechanical tomato harvester study.

Ninety acres are used as a base for the harvester. If 4.73 acres are harvested per day, 90 acres will require 19 days. Nineteen days was the average for harvesters to be operated in 1970-71.

The transplanter was assumed to be limited to 76 acres each year. If the transplanter operates an average of 8 hours each day during the planting season and it takes 95 minutes to plant an acre then 15 days would be used to plant 76 acres.

2/ The purchase price of machinery is quite variable. For example, there are power bedders, sled bedders, new bedders and used bedders; or there are self propelled harvesters, pull type harvesters, new harvesters and used harvesters and also different makes of each type of machinery. The purchase prices entered approximates an average of what a farmer might have to pay in 1979.

3/ The interest calculation determines the average value of the machinery for the period of ownership and then multiplies that average value by the current interest rate.

Land Charge; The land charge of 55, 85, and 115 dollars per acre is 150 percent of the land charge entered for general crop production. It is felt by most landowners that specialized crop production results in more trips over the field and more soil compaction. Also, most landowners feel that the better land is devoted to the specialized crops. These two factors represent the reasoning for higher rent.

It is obvious that the 55, 85, and 115 dollars for rent does not generate enough to pay for the $2500 plus land prices prevalent in the tomato producing area of Ohio. Part of current land price must be allocated to speculation. If a land rent of $85 is considered and $15 per acre is spent for real estate taxes, insurance and the fixed costs associated with tile then $70 remains for an interest return to the land investment. On $2500 land a $70 annual return gives a 2.8 percent annual return to the land. If a landowner strives for a 12 percent annual return from a land investment the remaining 9.2 percent would need to come from annual appreciation.

No cost is itemized for principal payment. Principal payment on land, a non-depreciating asset, adds to networth and is not a cost of production.

The increasing land charge with increasing yields is to recognize the differences in quality of land. Part of the yield differentials which occur are due to land quality.

Management Charge: The management charge is in recognition of the role of decision making. Labor in the budget to this point has represented an amount for employing machine operators, sorters, people to transplant and hoe. The management charge is to recognize marketing responsibilities, employer duties, purchasing decisions, and the role of choosing among cultural practices.

The rate of management compensation is calculated at 5 percent times the gross income. Using the same rate for other crops, a corn crop grossing $220 has an $11 management charge contrasted to the $78 for a $1564 tomato crop.

Total Fixed Costs:

Basically fixed costs are costs which will continue whether tomatoes are grown or not. Also, these costs will continue if crops other than tomatoes are grown. A couple illustrations; most of the housing costs will continue whether tomatoes are grown or not, even the management charge could be thought to continue since the ability to grow tomatoes is possessed by the farmer. On a year to year consideration of crop production the fixed costs should not affect the decision of which crop to grow. Fixed costs are an important consideration when making potentially long term decisions like a land or tomato harvester investment.

Return Above Variable Costs:

This calculation was made by subtracting the total variable costs from the gross receipts. This is the most important item of information in the budget. Since fixed costs continue whether a crop is grown or not and irregardless which crop is grown maximizing the returns above variable costs maximizes returns to the fixed costs. This type of thinking yields the greatest profits.

Return Above Total Costs:

In the long run there needs to be a return above the total costs of production. The considerations of profitability for assets with more than a one year life is best done at the time of purchase of the asset. After long term assets are purchased the return above variable costs are most important unless liquidating an asset is one alternative.

SUMMARY

As machine harvest tomatoes are compared with other crop budgets the potential profitability is very favorable, Table 3.

Table 3. Comparison of Returns from Various Crops (Medium Yields).

	Machine Harvested Tomatoes	Hand Harvested Tomatoes	Pickling Cucumbers	Sugar-beets	Soybeans	Corn
Yields	23 Tons	24 Tons	12 Tons	20 Tons	35 Bu.	110 Bu.
Gross Receipts	$1564	$1632	$1488	$480	$210	$220
Variable Costs	$ 660	$1233	$1127	$246	$ 75	$100
Fixed Costs	$ 412	$ 302	$ 280	$178	$115	$119
Total Costs	$1072	$1535	$1407	$424	$190	$219
Return Above Variable Costs	$ 904	$ 399	$ 361	$234	$135	$120
Return Above Total Costs	$ 492	$ 97	$ 81	$ 56	$ 20	$ 1

Source: 1979 Crop Budgets prepared by Farm Management Faculty, Ohio State University.

As crops are compared for any farm a budget should be individually prepared as suggested by the Your Budget column in Table 1. Prices and quantities of any or all budget items could well differ from farm to farm.